



# California Hydrogen Highway Blueprint

## Implementation Topic Team

### Sub-team C/S.2.e – Clearance Distances

*Implementation Topic Team Public Hearing*

*August 31, 2004*

*CalEPA, Sacramento, CA*



$$\left[ \frac{p^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

**California Hydrogen Highways**

[www.hydrogenhighway.ca.gov](http://www.hydrogenhighway.ca.gov)

## Sub-team C/S.2.e – Clearance Distances

### What is Clearance Distance?

- Clearance Distance = Separation Distance = Setback Distance – distance prescribed by a Code or recommended by a Standard between a piece of equipment containing potentially hazardous material (e.g. fuel) and other objects (buildings, equipment, etc.) and public. Clearance Distances are established in order to provide minimum safety for installation and operation of equipment and to either:
  - Protect the said piece of equipment from potentially hazardous environment; or
  - Protect surrounding objects and public from the said equipment.



$$\left[ \frac{p^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

# Sub-team C/S.2.e – Clearance Distances

## Why Clearance Distances is an Issue?

- Clearance Distances greatly affect footprint of refueling and energy stations:
  - Not an issue for industrial plants
  - An issue for commercial and residential applications – may require real estate that is not always available
    - Alternatives to current clearance distance requirements exist but need to be validated and incorporated into model codes
- NFPA work on industrial gases was initiated by CGA in 1959, initially adopted in 1961 and officially adopted in 1963 as NFPA 567. Officially redesignated as NFPA 50A in 1969
- *Thus, clearance distances were developed over 40 years ago by CGA for industrial operations. They were not developed for hydrogen use in retail locations by the general public*



$$\left[ \frac{p^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

# Sub-team C/S.2.e – Clearance Distances

## U.S. and Canadian Effort

- U.S. DOE Separation Distances project (in collaboration with Canadian Transportation Fuel Cell Alliance - CTFCA) led by Sandia National Laboratory:
  - Provide experimental data and verified simulations of hydrogen behaviour that will enable the establishment of safe, validated minimum clearance distances
  - Develop scientifically based guidelines that could be used as input to the hydrogen codes and standards



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# Sub-team C/S.2.e – Clearance Distances

## U.S. and Canadian Effort

- The DOE effort includes development of software that shows the layout of a typical fueling station with the current setback requirements in the International Fire Code.
- The program allows the user to step through the ICC requirements that affect the footprint of a fueling station, for example, the setbacks for dispensers, signs, and storage tanks.
- The next generation of this program will be linked to a flexible database that will, for example, contain setback requirements of the NFPA and other requirements of state and local authorities having jurisdiction that could affect station footprint.
- DOE plans to further develop the software and database to assist code officials and industry create a set of footprints that can serve as starting points for locating hydrogen fueling stations in, for example, urban, suburban, and rural areas of California where CHH stations may be located



$$\left[ \frac{p^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

# Sub-team C/S.2.e – Clearance Distances

## U.S. and Canadian Effort

- CTFCFA effort also includes *Intelligent Virtual Refueling Station Project* that provides a user with real time interaction with computer database and allows “constructing” a refueling station using variety of hydrogen generation, delivery and storage technologies
- The program takes into account current clearance distances prescribed by Canadian Codes



$$\left[ \frac{p^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

# Understanding H<sub>2</sub> Properties

Property	Hydrogen	Methane	Propane	Gasoline Vapour
Buoyancy (density relative to air)	0.07	0.55	1.52	3.4 - 4.0
Molecular Diffusion Coefficient (cm <sup>2</sup> /sec)	0.61	0.16	0.12	0.05
Flammability range, (vol % in air) LFL - UFL	4 - 75	5 - 17	1.7 - 10	1.4 - 8
Explosive range, (vol % in air) LEL - UEL	18 - 59	5.7 - 14	2.7 - 7	1.4 - 3
MEIM (vol % in air)	29	9	5	2
Explosive energy (relative to H <sub>2</sub> by vol)	1	3.5	10	22 +

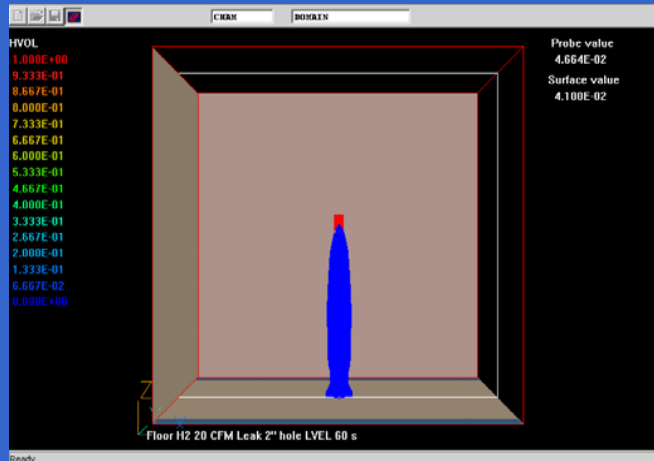


$$\left[ \frac{p^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

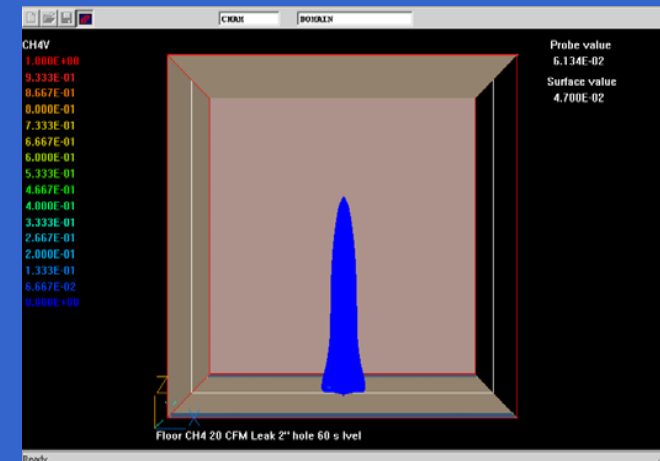
# Understanding H<sub>2</sub> Properties - LFL

20 CFM Leak 60 sec:

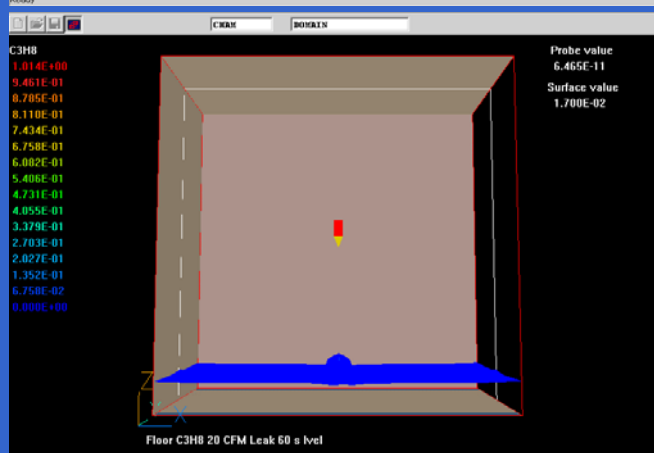
H<sub>2</sub>



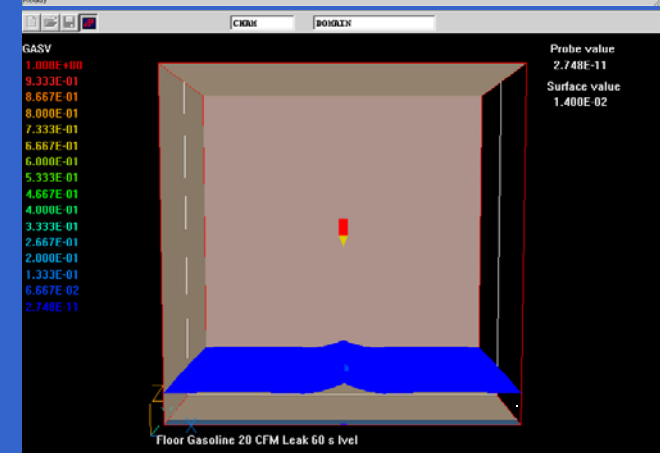
CH<sub>4</sub>



C<sub>3</sub>H<sub>8</sub>



Gasoline

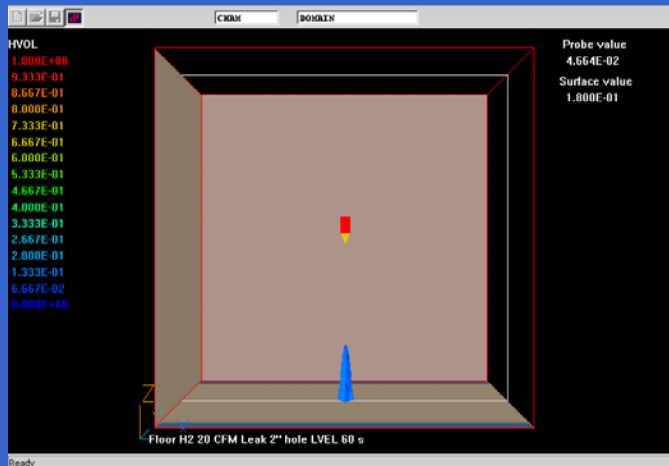


$$\left[ \frac{P^2}{2\mu} + V(r) \right] \psi(r) = E \psi(r)$$

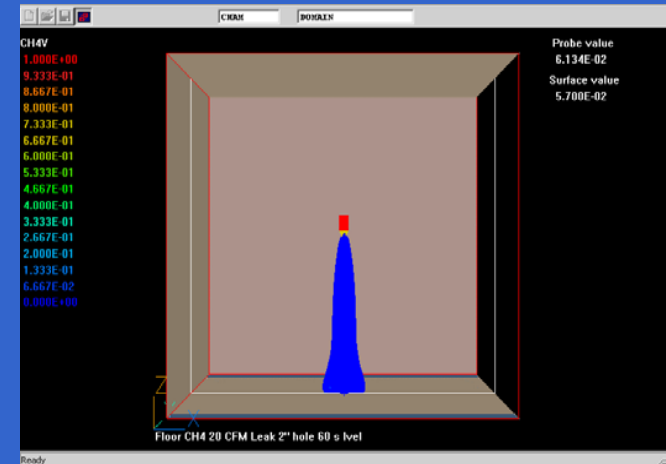
# Understanding H<sub>2</sub> Properties - LEL

20 CFM Leak 60 sec:

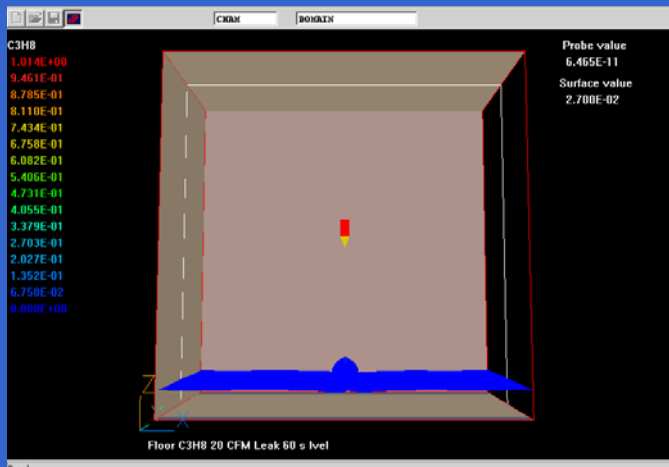
H<sub>2</sub>



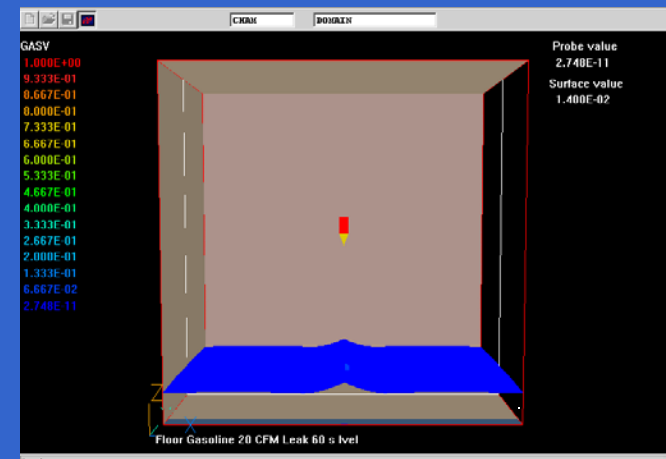
CH<sub>4</sub>



C<sub>3</sub>H<sub>8</sub>



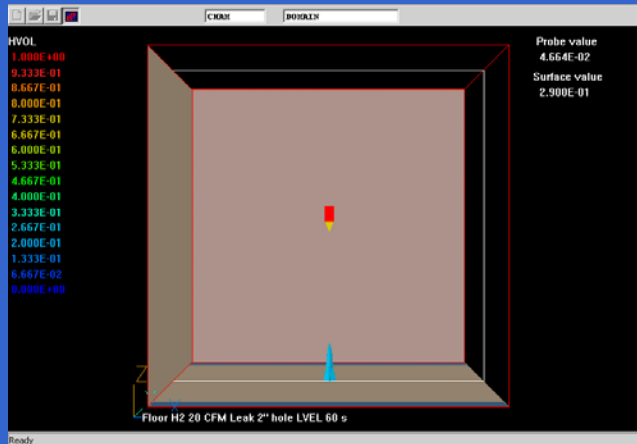
Gasoline



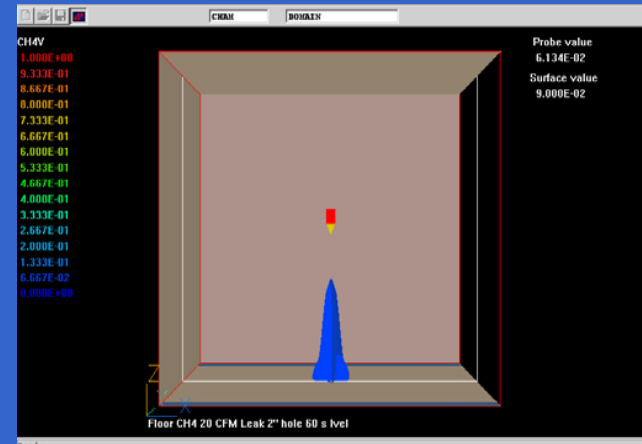
# Understanding H<sub>2</sub> Properties - MEIM

20 CFM Leak 60 sec:

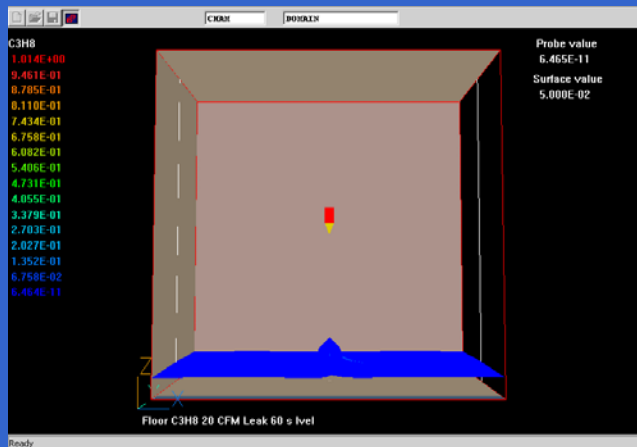
H<sub>2</sub>



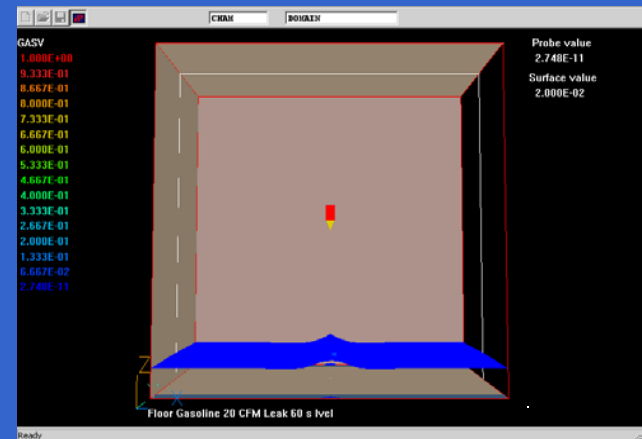
CH<sub>4</sub>



C<sub>3</sub>H<sub>8</sub>



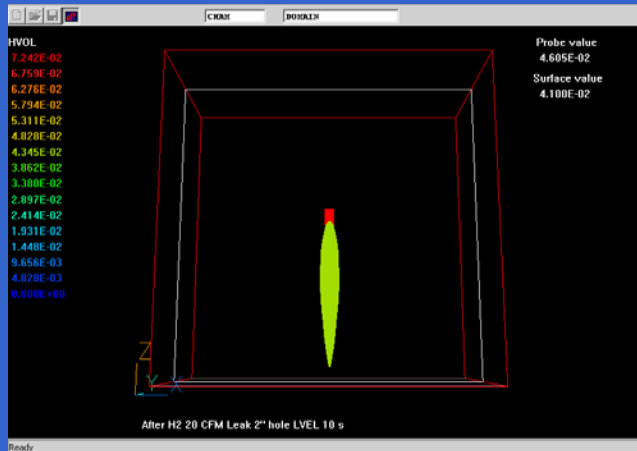
Gasoline



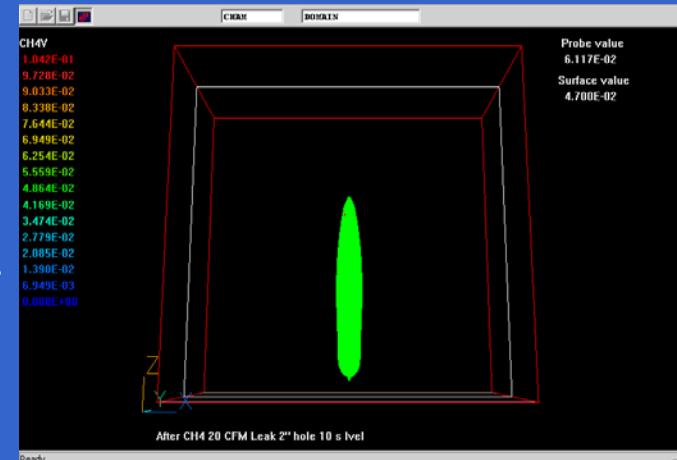
# Understanding H<sub>2</sub> Properties - LFL

After Leak 1 sec:

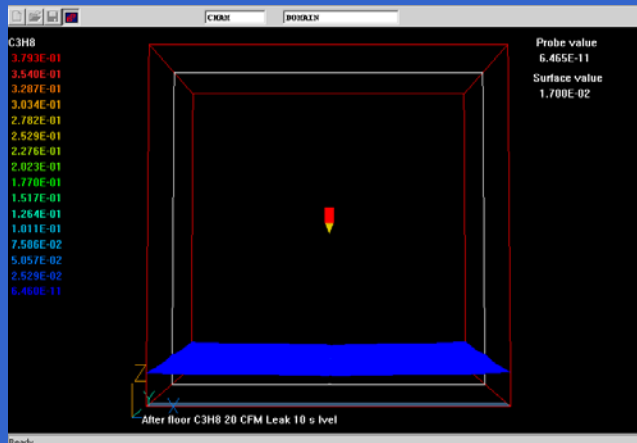
H<sub>2</sub>



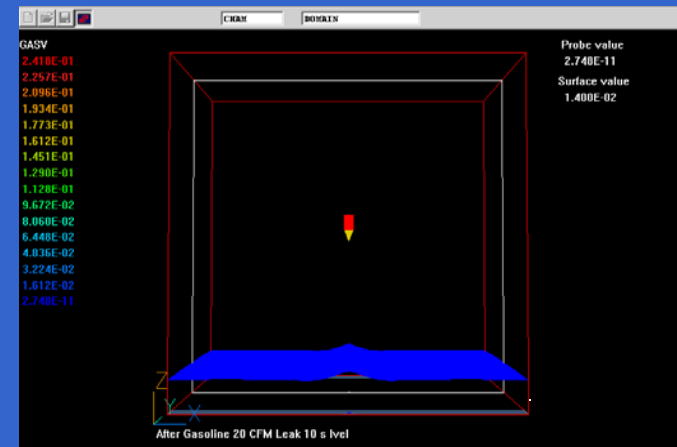
CH<sub>4</sub>



C<sub>3</sub>H<sub>8</sub>



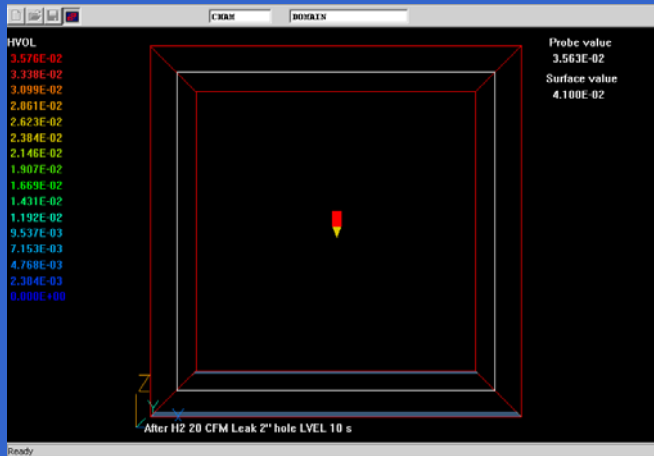
Gasoline



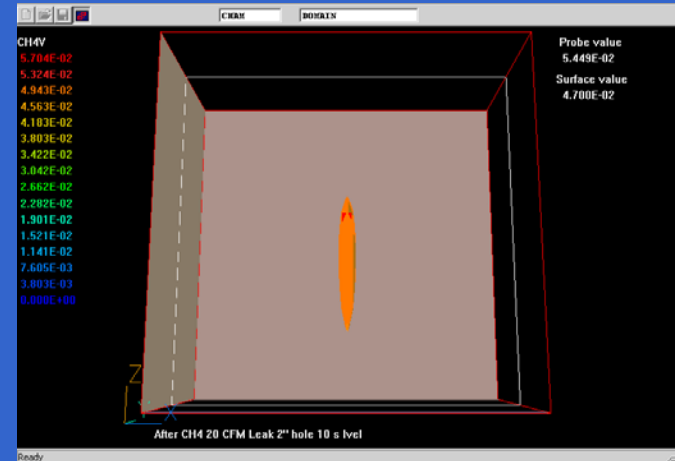
# Understanding H<sub>2</sub> Properties - LFL

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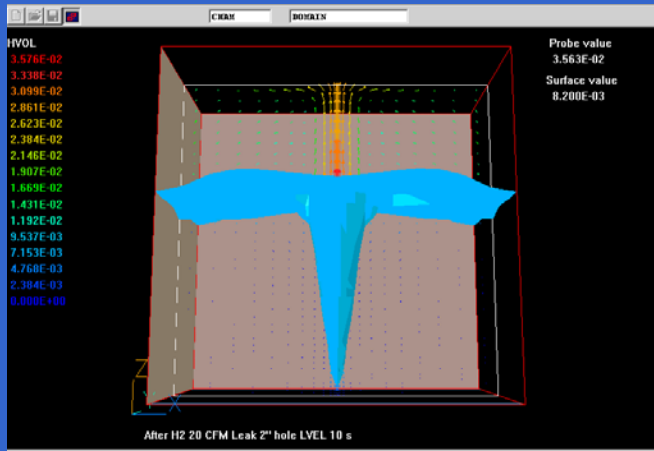
H<sub>2</sub> LFL



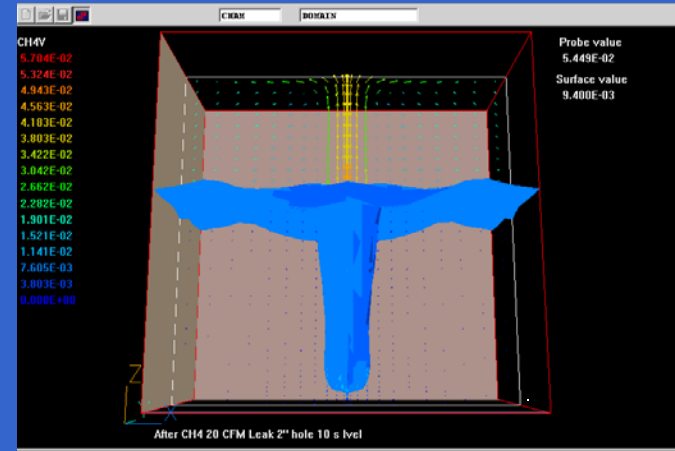
CH<sub>4</sub> LFL



H<sub>2</sub>  
20% LFL



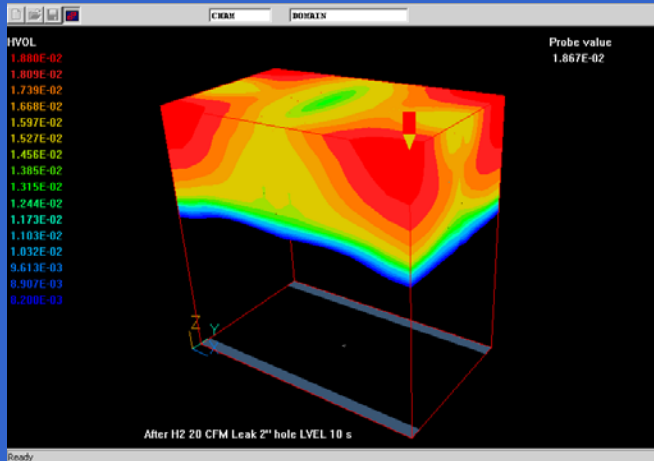
CH<sub>4</sub>  
20% LFL



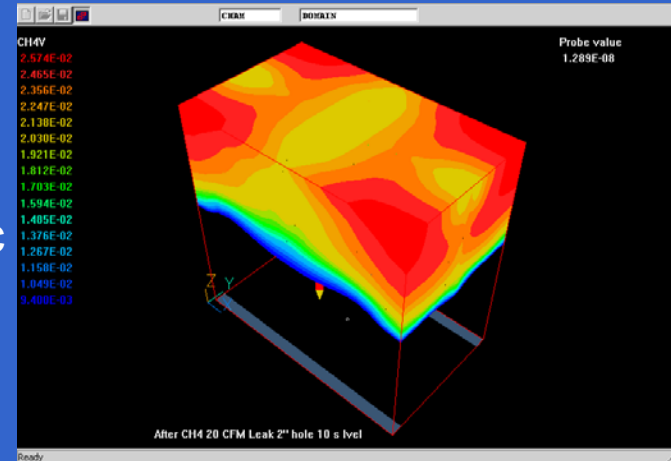
# Understanding H<sub>2</sub> Properties - LFL

After Leak 10 sec:

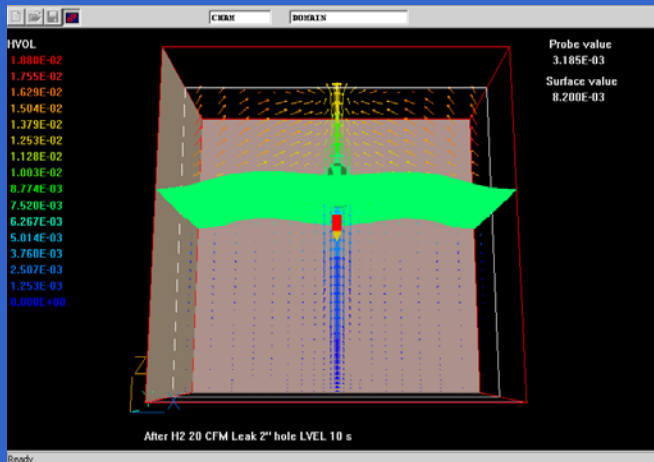
H<sub>2</sub> Conc



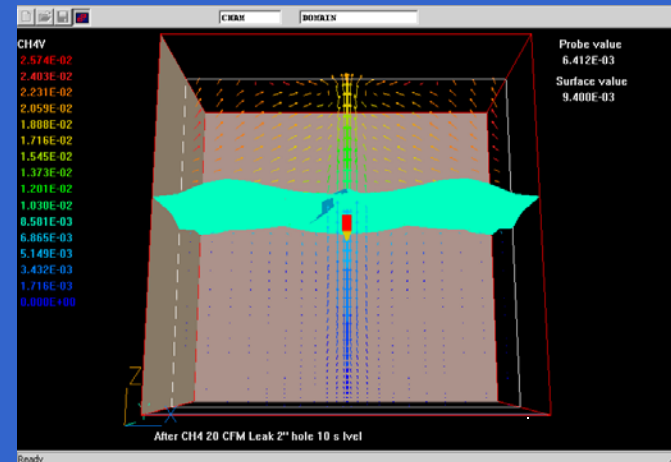
CH<sub>4</sub> Conc



H<sub>2</sub>  
20% LFL



CH<sub>4</sub>  
20% LFL



# Sub-team C/S.2.e – Clearance Distances

## Recommendations

- It is recommended that the State of California develop a collaboration with the program of the U.S. DOE Hydrogen, Fuel Cells and Infrastructure Technologies Office to utilize and contribute to the development of state and national templates for permitting and regulatory approvals of refuelling and energy stations.
- Templates of Codes and Standards and Regulations developed by SCAQMD for a number of South Coast regions should be coordinated with the U.S. DOE umbrella activity



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